ECG Analysis Summaries

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1 QRS Analysis Algos

1.1 Signal Derivatives and Digital Filters

- Typical f components in the range of 10-25 Hz, so most algos use a filter bank to attenuate other signal artifacts from P,T waves, baseline drift, incoupling noise.
- For P,T waves use high pass filtering, for incoupling noise actually need a low pass filter, giving a bandpass filter from 10-25 Hz.
- Some do it separately , some only take the high pass part of it.
- Most algos use some kind of decision rules to reduce the number of false positives.

1.1.1 Derivative Based Algos

- HPF realized as a differentiator. Mostly first order, some also second order. Some cases a linear combination as well.
- Detection by comparing the feature against a threshold.
- Also complemented by heuristically found features

1.1.2 Digital Filters

- Two different lpf with different cut-off freq, subtraction gives bpf.
- Passed onto simple m+-time step averaging.
- MOBD (multiplicatio of backward difference) : kind of AND all algorithm and some consistency conditions.
- Simple peak detection search by comparing the max and following till v/2 of the signal. Mark the highest peak.
- Do a form of lc of peak level and simple noise level and update, eventually threshold reached.
- Another method : max of each segment compared to an adaptive noise level and adaptive peak estimate and classified depending on distance to each other.
- Generalized digital filters also proposed.

1.2 Wavelet, Singularity, Filter Bank

- Use wavelet transform, in some sense similar to stft. Use discrete wavelet transform.
- 32 band filter bank used to downsample subband signals.

1.3 Neural Network Based Methods

1.3.1 Neural Networks

- ANN for non-linear signal processing. Mostly MLP, RBF, LVQ used. RBF closely related to fuzzy logic methods.
- LVQ has input layer, competitive layer, linear layer, competitive automatically learns to classify input vectors into subclasses where max subclasses is number of neurons.
- MLP, RBF trained using supervised, LVQ trained in an unsupervised manner.

1.3.2 Neural Networks as Adaptive Non-linear Predictors

- Since ecg contains mostly non-QRS segments, nn converges to a point where samples from non-QRS segments are well predicted, and segments with sudden changes (QRS segments) follow a different statistics and lead to sudden increase in the prediction error, which in itself can be used as a feature signal for QRS detection.
- Non-linear prediction using mlp, trained online and output is further passed through matched filter.

1.3.3 LVQ for QRS-detection

- Train a discrimination between QRS and PVC contractions.
- Not very good results, but once trained offers fast computations.

1.4 Additional Approaches

1.4.1 Adaptive Filters

- Simple prediction filter to learn the weights using least mean square error.

1.4.2 Hidden Markov Models

- Possible states are P-wave, QRS, T-wave. Whole state sequence is inferred at once.
- Disadvantage is large computation complexity.

1.4.3 Mathematical Morphology

- Use of erosion and dilation.
- This gives a feature signal and QRS again got using thresholding.

1.4.4 Matched Filter

- Improves SNR.
- AMCD : Average magnitude cross difference method : computationally inexpensive alternative.

1.4.5 Genetic Algorithms

- Genetic algorithms applied to combined design of optimal polynomial filters for the preprocessing and decision stage.
- Decision stage mainly adaptive threshold, and optimized in conjunction with polynomial filters.

1.4.6 Hilbert Transformed Based QRS-detection

- Hilbert transform of the signal is used to compute the signal envelope.
- LPF to avoid ambiguity of peak detection.

1.4.7 Length and Energy Transforms

- Both assume that ecg is a vector.
- Length and energy transform are better features than conventional transforms of feature extractions.

1.4.8 Synctactic Methods

- Signal assumed to be concatenation of linguistically represented primary patterns i.e. strings. Use grammar to search for code strings.
- Due to computational efficiency mostly use line segments as primitives for the signal representation.

1.4.9 QRS Detection Based on MAP estimate

- Prior of linear combination of pulse-shaped peaks.

1.4.10 Zero-crossing based QRS Detection

- After bpf a high freq sequence is added. Non-QRS segment has more zero crossing than QRS segment.

1.5 Benchmark Databases

1.5.1 MIT-BIH Database

- Ten databases for various test purposes.
- Most frequently MIT-BIH Arrythmia database is used. Contains 48 half hour recordings of annotated ECG with sampling rate of 360Hz and 11bit resolution over 10mV range. For some cases detection is quite difficult because of abnormal shapes, noise and artifacts.

1.5.2 AHA Databse

- 155 recordings of ambulatory ECG for Ventricular Arrythmia Detectors.

1.5.3 Ann Arbor Electrogram Libraries

- Not relevant.

1.5.4 CSE Database

- Contains 1000 multi-lead recordings (12-15 leads).

1.5.5 Other standard Databases

- European ST-T
- QT
- MGH
- IMPROVE

- PTB